AFRL-HE-WP-TR-2004-0158

United States Air Force Research Laboratory

A SOFTWARE TESTBED FOR DISPLAY EVALUATION

Matthew S. Middendorf

Middendorf Scientific Services, Inc.
Medway OH 45341

Nicole M. Guilliams
Annie B. McLaughlin

Human Effectiveness Directorate
Warfighter Interface Division
Wright-Patterson AFB OH 45433-7022

August 2004

Interim Report for the Period August 2003 to August 2004

Human Effectiveness Directorate
Warfighter Interface Division
2255 H Street
Wright-Patterson AFB OH 45433-7022

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AFRL-HE-WP-TR-2004-0158

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

//Signed//

MARIS M. VIKMANIS
Chief, Warfighter Interface Division
Air Force Research Laboratory

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. REPORT DATE (DD-MMM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From – To)
August 2004	Interim Report	August 2003 to August 2004

4. TITLE AND SUBTITLE

A Software Testbed for Display Evaluation

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
62202F

6. AUTHOR(S)

*Matthew S. Middendorf
**Nicole M. Guilliams
**Annie B. McLaughlin

5d. PROJECT NUMBER
7184

5e. TASK NUMBER
08

5f. WORKUNIT NUMBER
72

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
*Middendorf Scientific Services, Inc.
Medway OH 45341

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
**Air Force Research Laboratory
Human Effectiveness Directorate
Warfighter Interface Division
Air Force Materiel Command
Wright-Patterson AFB OH 45433-7022

10. SPONSOR / MONITOR'S ACRONYM
AFRL-HE-WP-TR-2004-0158

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The purpose of this report is to make publicly available a software application testbed and its user manual that enable research on visual displays using a battery of tasks. The software currently employs two tasks, a multi-element tracking task and a cognitive vigilance task, which support research on attention and visual tracking. The software was developed for a multi-layer (depth) display, but also supports single or side-by-side monitors. The experimenter interacts with the software via standard dialog boxes which allows easy configuration the tasks and control of experimental parameters.

15. SUBJECT TERMS

Multi-Layer Display (MLD), Software, Microsoft Foundation Classes (MFC)

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON:
a. REPORT	b. ABSTRACT	c. THIS PAGE			Nicole M. Guilliams
UNCLAS	UNCLAS	UNCLAS	UNLIMITED	12	19b. TELEPHONE NUMBER *(Include area code)* (937) 656-7013

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Executive Summary

The purpose of this report is to make publicly available a software application testbed and its user manual that enable research on visual displays using a battery of tasks. The software currently employs two tasks, a multi-element tracking task and a cognitive vigilance task, which support research on attention and visual tracking. The software was developed for a multi-layer (depth) display, but also supports single or side-by-side monitors. The experimenter interacts with the software via standard dialog boxes which allows easy configuration the tasks and control of experimental parameters.

Initial studies utilizing the software investigated the effects of depth and transparency in relation to performance decrement with concurrent task performance by eliminating the effects of occlusion. Analyses of the first study suggest that both depth and transparency played a role in reducing the deficits introduced by occlusion, and also reduced perceived mental workload. Results of a second study verified the positive effects of transparency, but failed to replicate the significance of the depth effect. Further details of these studies can be accessed through a corresponding technical report.

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Display Evaluation Testbed Users Manual

This document describes how to use software that was developed to drive a multi-layer display (MLD). Two MLDs were evaluated using this software to investigate the potential benefits that depth may provide. However, the software is not limited to use with the depth display. It can also be used with a single monitor or two side-by-side monitors.

1) **Brief Hardware Description**: The MLDs, manufactured by Deep Video Imaging, consist of two LCD panels that are mounted one in front of the other. The two panels in the 18mxG MLD are separated by 12 mm and have a size of 457 mm diagonal. The panels in the 15gX MLD model are separated by 40 mm with the front panel measuring 380 mm diagonal and the back panel measuring 457 mm diagonal. The front panels are transparent when filled with white pixels, and nearly 100% opaque filled with black pixels. The two LCD panels are commonly referred to in the software as the near plane and far plane. A dual head video card is required to drive the two planes.

2) **Software Description**: The software was developed by Matt Middendorf of MSSI, under subcontract to Sytronics, Inc. It is written is C++ using OpenGL for the display generation. The software was developed using Microsoft's Visual Studio, and is organized into two projects. The first project is a windows-based application that allows the users to enter setup and control parameters via dialog boxes. The second project is the real time process that generates the displays, interfaces with the human subject, and collects data. The software was organized in this manner to take advantage of the Microsoft Foundation Classes (MFC) and OpenGL, which are mutually exclusive. Information is passed from the setup application/GUI to the real time application using a control file.

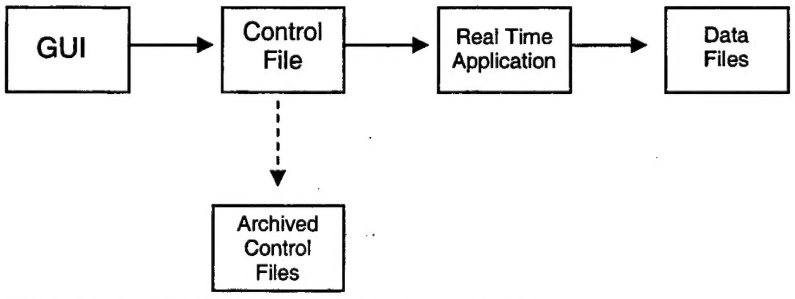


Figure 1. Illustration of information flow for system control.

   a. File Locations: All source code is contained on the CD. The two executables need to be copied to the local hard drive as specified below. The two short cuts need to be copied to the desktop.
      i. *Executables*: C:\DDTestBed
      ii. *Control File*: C:\DDTestBed\DDTBControlFile.dat

iii. *Data Directories*: C:\MLD\EXPeee\SUBsss, where eee is the experiment number and sss is the subject number. Under the subject folder are sub-folders for each task type. These sub-folders contain data files for each individual trial.

iv. *Data Files*: The format of the data files is SsssTttt.BTn and SsssTttt.DPn, where sss is the subject number, ttt is the trial number, and n is the task number. The files containing BT in the extension are from the ball tracking task and files containing DP are from the digit pair task

v. *Aggregate Data Files*: At the subject folder level there are files that contain data across trials for each task type. The format of these files is Ssss.BTn and Ssss.DPn, where sss is the subject number and n is the task number.

vi. *Summary Statistic Files*: At the subject folder level there is a file that contains summary data for each trial. This file currently exists only for the digit pair task. The data is summarized across events. The format of this file is Ssss_SS.DPn, where sss is the subject number and n is the task number.

b. Control File Copies: A control file is used to pass information from the setup application/GUI to the real time process. Copies of the control file are maintained in two other locations.

i. *Subject Folder*: A copy of the control file is placed in the subject folder. This copy is used to pre-populate all of the fields in the setup application dialog boxes the next time the application is run to facilitate ease of use.

ii. *Archive Folder*: Each time a new control file is written by the setup application, the existing control file is copied to the archive directory (C:\DDTestBed\Archive) with a new extension (.001, .002, etc.). A historical record of the control files is maintained in case there is ever any question about what conditions a subject was run under. At the conclusion of an experiment the archived control files should be moved to an experiment-specific folder.

3) **Experiment Number**: All data collected with this software is organized on the local hard drive according to experiment number and subject number under the root folder MLD\. The initial dialog box allows the selection of the experiment of the experiment number and subject number. If demo mode is selected, data files are not created and the subject number is not required.

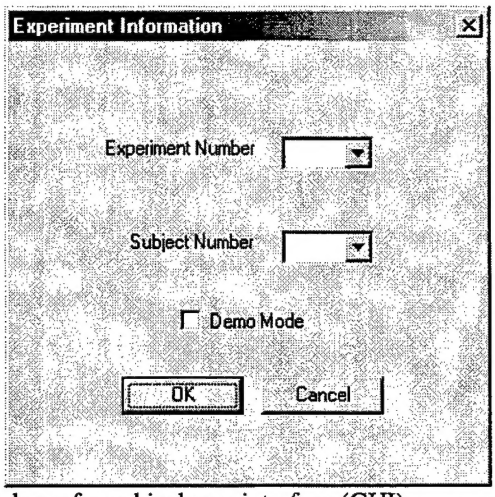


Figure 2. Initial dialog box of graphical user interface (GUI).

4) **Session Information** – The session information dialog box allows the user to begin controlling experimental conditions. Trial length, initial delay, trials per block, number of blocks, display configuration, and device model are all available for manipulation. Figure 3 illustrates the corresponding dialog box.

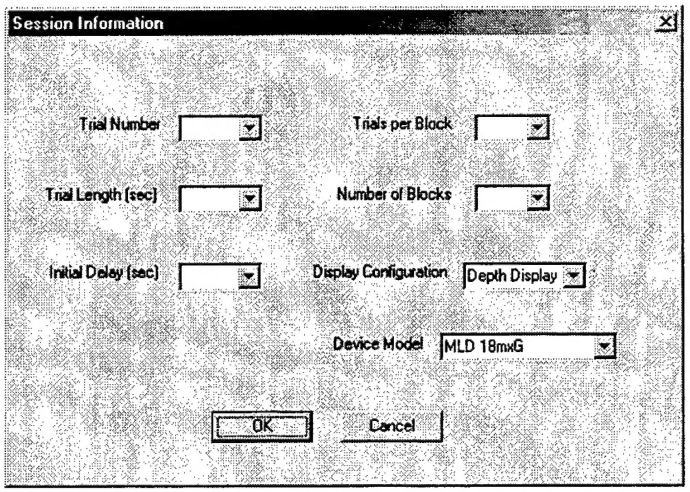


Figure 3. Session Information dialog box.

5) **Task Descriptions**: The task selection dialog allows various tasks to be assigned to either display plane. The two tasks currently available are a Ball Tracking Task (Multiple Elements Tracking Task), and a Digit Pairs task.

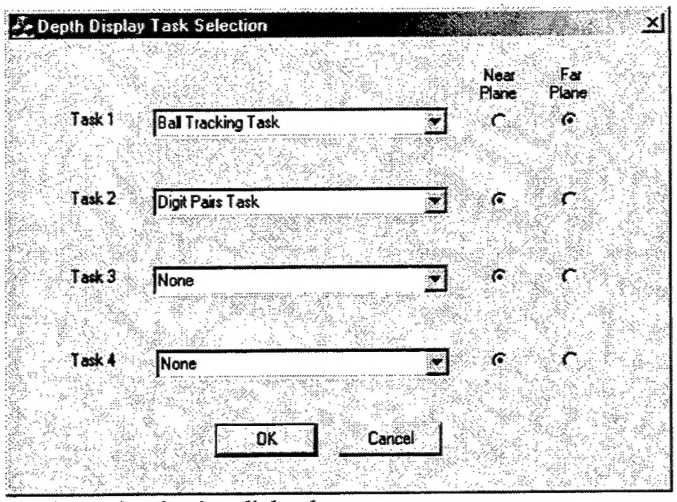


Figure 4. Depth Display task selection dialog box.

a. Ball Tracking Task: The participant's task is to track a subset of balls (i.e. targets) from the total number of moving balls. The target balls will blink initially, and then turn to solid so that all balls are identical. Various motion algorithms can be selected to govern the movement of the balls.

When time expires, the balls will stop moving and the participant must indicate which balls are the targets by selecting them with the mouse. Clicking on a selected ball a second time will deselect the ball. After making the selections, the participant can accept the choices or reject them and start over.

Selection feedback indicates which balls the participant has selected with the mouse. Correct target feedback displays the target balls as unfilled circles once the selections have been accepted. Both selection feedback and correct target feedback can be toggled.

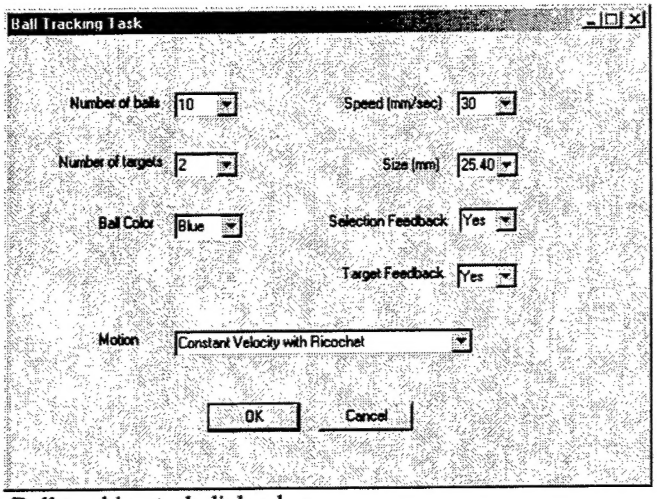


Figure 5. Ball tracking task dialog box.

b. Digit Pairs Task: This task includes two digits on a pop-up window located on the screen. The participants' task is to determine if the two digits meet the criteria to be a critical signal. Currently there is only one definition of a critical signal available. That is, if these two digits differ by no more than one, *and* sum to a value between 4 and 14 inclusive.

If a critical signal is detected, the Signal button should be selected by either pressing the "left-pointing" arrow key or left-clicking on the Signal button with the mouse (depending on the experimental condition). If the digit pair is not a critical signal, respond by pressing the "right-pointing" arrow key or using the mouse to click on the Non-Signal button.

Participants have a fixed amount of time to respond to the digit pairs. The responses will be followed by a "beep," indicating that a response has been recorded within the allowable time limit. If a response is outside of the response window, a "beep" will not be heard. The pop-up windows remain on the screen for the full selected duration regardless of when the participant provides an input.

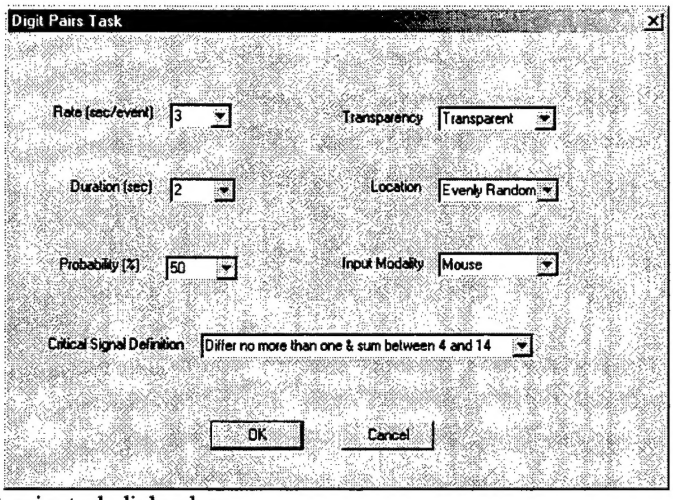


Figure 6. Digit pairs task dialog box.

6) **Time Line**: The trial length should be carefully chosen so that the experimental manipulations can be achieved. For example, the trial length and event rate for the digit pairs task should be selected so that the trial doesn't end in the middle of an event. To accomplish this, ***the trial length divided by the event rate should result in a whole number***. If "Evenly Random" locations are selected for the digit pairs task, the above calculation should produce a whole number that is a multiple of five

7) **Task Order**: The tasks are displayed in the order they are selected in the task selection dialog box. Therefore, the ball task may need to be selected ahead of the digit pairs task to get the proper transparency or occlusion effect.

8) **Integrity Checks**: If the experimenter selects parameters, while running the setup application, which will not allow the experimental manipulations to be

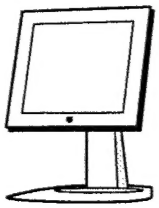
achieved in real time, an integrity check will be generated. A message box will be presented detailing the exact problem. The experimenter can abort the run, or continue with the trial even if the desired experimental manipulations can not be achieved.

9) **How to Run the System**:
   a. The display resolution needs to be set to 768x2048, and the desktop background needs to be white.
   b. Double click the "Depth Display GUI" icon on the desktop.
   c. Fill in all of the required fields on the dialog boxes. Note that demo mode does not require a subject number; it is always zero by default. Additionally, data files are not collected for demo mode.
   d. When the "Start Trial" message box is displayed, seat the subject in front of the depth display and let the subject initiate the trial.

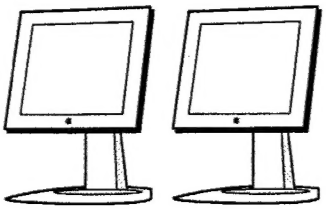
10) **Video Card Setup**: The video card used in the development system is the NVIDIA Geforce4. There is a desktop manager wizard for setting up the card and driver. The wizard is found under the advanced settings in the display properties tab. Two important settings are: do not allow spanning across monitors (Windows tab), and reposition dialog boxes at cursor.

11) **Display Configurations**:

a. One Monitor
   - 3:4 Aspect Ratio
   - 1 display plane
   - Uses Alpha blending



b. Two Monitors
   - 3:8 Aspect ratio
   - 2 Display Panes
   - Uses Alpha Blending



c. Multi-Layer Display
   - 3:8 Aspect Ratio
   - 2 Display Panes
   - No Alpha blending